

MACHINE TO MACHINE COMMUNICATION BASED ELECTRICITY MONITORING AND BILLING SYSTEM

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ABSTRACT

Machine-to-machine (M2M) communications provides real-time monitoring and control without the need for human intervention. In this paper we propose a prototype which uses machine-to-machine (M2M) communications to realize automated electricity monitoring and billing system using Smart meter. The Smart meter transmits power consumption information to utilities via communication networks. The users can logon to web server connected to database to monitor and track their power consumption presented in graphical form. The information in database is further used to generate electricity usage bills for the consumers. Electricity users benefit from the smart meter as they have a direct usage review possibility. With electricity being monitored and bill generation automated, grid companies will benefit and receive a much more actual and accurate overview of energy consumption in their region.

KEYWORDS: M2M - Machine-to-Machine, Smart Meter, GPRS, Wireless Communication Systems

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INTRODUCTION

The purpose of this paper is to develop a prototype of smart meter with the help of machine-to-machine communication. Residential energy consumption tends to grow rapidly as more and more home appliances and consumer electronics are installed. Hence, it is important for the users to have track of the energy consumption.

The current electricity metering system with the old meters is not a digitally smart system. The number of manual efforts involved here are quite large and with manual intervention possibility of error is high too leading to adjustments or incorrect billing.

Mico Dujak, Vedran Parac, Marko Durasevic and Ajdin Heric presented system to collect data from gas, water and electrical meters with optical cameras based on M2M Service Enablement (M2M SE) Node developed in Ericsson.(1)

The new machine to machine communication based smart meters would communicate directly with the utility home office, without any manual intervention. Energy savings and an increased security of supply will be main drivers. Many advantages are attributed to smart metering, including lower metering cost, energy savings for residential customers, more reliability of supply, variable pricing schemes to attract new customers.

Smartmetering (2) will provide grid operators with a tool to detect fraud. Gathering all data, the grid operator will be able to predict electricity flows more accurately. Introduction of smart metering seems also a logical step in a world where all communication is digitalized and standardized (Internet, E-mail, SMS, chat boxes etc.) and where cost of 'digital intelligence' are still rapidly decreasing.

Smart metering infrastructure offers the possibility for additional energy related services such as demand side management and realization of virtual power plants. The future of smart metering will depend heavily on the policy and decisiveness of the governmental bodies involved.

M2M COMMUNICATION

In recent years, the topic of M2M communications (3)(4) has attracted much attention from industry and research community, mainly driven by the factors such as the emergence of wireless communication systems (e.g., GSM/GPRS, WiMAX, and wideband code-division multiple access [WCDMA]) in the Internet has become the premise for the advance of M2M communications. The network infrastructures of these communication systems are already in place, and can be adopted in M2M communications.

M2M is a broad term as it does not pinpoint specific wireless or wired networking information and communications technology.

M2M uses a device (such as sensor or meter) to capture an event (such as temperature, inventory level, etc.), which is relayed through a network (wireless, wired or hybrid) to an application, that translates the captured event into meaningful information.

The goal of M2M services is to automate decision and communication processes.

SYSTEM DESIGN

The proposed system mainly consists of 4 domains; the sensor domain, telemetry domain, business domain and user domain (1).

The sensor domain comprises of sensor unit to measure power consumption which is processed and sent over to server using wireless communication.

The telemetry domain is responsible to retrieve data from server and store that data in database. The database is required for web server to plot and display the consumption as and when user requests. Business domain is an application (for example web application) which presents data from telemetry domain to end-users in the User domain.

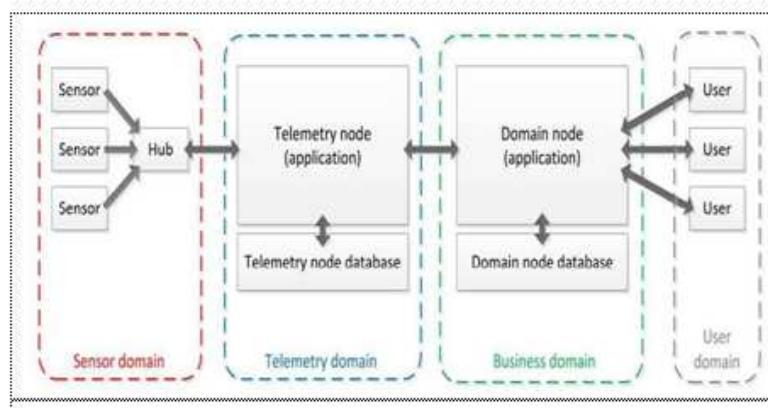


Figure 1: Domains in System

The system will provide updated information regarding energy consumption whenever requests come from authenticated user to the web server possibly from far end place over the internet.

SYSTEM IMPLEMENTATION

The methodology of this project design can be divided into two sections; hardware and software implementations.

- **Hardware Implementation**

The hardware implementation consists of development of the main controller, sensor nodes and the wireless communication module.

- **Main Controller- ARM 7 (LPC 2148)**

Main controller is the most important part of the system in this project. Main controller will be the interface between the user and the system and used to process sensor readings.

The ARM7 processor LPC2148 is used as the main controller. The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-SCPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32 KB to 512 KB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate.(5)

- **Sensor Node – Wattmeter -ADE7755**

The ADE7755 a high accuracy electrical energy measurement IC is used to measure the power consumed by load. The only analog circuitry used in the ADE7755 is in the ADCs and reference circuit. All other signal processing (for example, multiplication and filtering) is carried out in the digital domain. This approach provides superior stability and accuracy over extremes in environmental conditions and over time. The ADE7755 supplies average active power information on the low frequency outputs, F1 and F2. These logic outputs can be used to directly drive an electromechanical counter or interface to an MCU. The CF logic output gives instantaneous active power information. This output is intended to be used for calibration purposes or for interfacing to an MCU. (6)

- **Wireless Communication Module - GPRS Modem**

The GPRS modem will play most important role of communicating between the sensor node &telemetry domain (to send consumption data to web server).

The Modem can be directly interface with 5V microcontrollers like PIC, AVR, 8051 Derivatives, Arduino and 3V3 Microcontrollers like ARM, ARM Cortex XX etc. Only 2 connections are required to use the modem. Connect RX pin of the modem to the TX pin of the microcontroller and TX pin of the modem to microcontroller's RX pin. The connected power supply (4.2v to 12v dc) should be capable of handling current up to 1A.

- **Software Implementation**

The software implementation focuses on the programming of the microcontroller using Embedded C using Keil µVision. MySQL, very popular and free database software, is used as database server.

The business domain application is designed by using VB graphical interface. After connected and logged into the database server through graphical interface, the authorized user will see their consumption status in form of graph. It also implements analysis for the energy consumption to draft out bill at end of set cycle period (Monthly/Weekly).

SYSTEM ARCHITECTURE

The architecture of proposed system can be seen below Figure

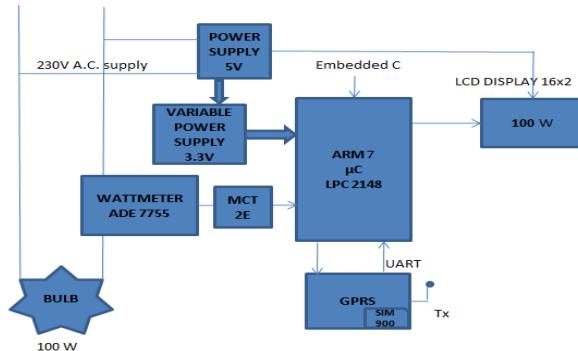


Figure 2

Watt meter captures the power consumption for the attached load in digital form.

The digital information is then processed using processor ARM 7 which is displayed on LCD and used as data for GPRS transmission packets.

The GPRS modem connects to APN over internet to reach web Server and post the information in transmission packets to database.

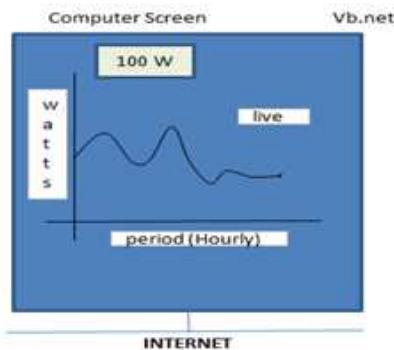


Figure 2: Business Domain Application

User will see the consumption status in form of graph when he connects over internet through graphical interface (business domain application).

The reporting application makes possible to see how much power is being used at different times of the day, week, month or year. It also does analysis of power consumption and generates the usage cost (bill) for specified period cycle.

SYSTEM PROTOTYPE AND RESULTS

Below Figure 4 shows the system hardware prototype

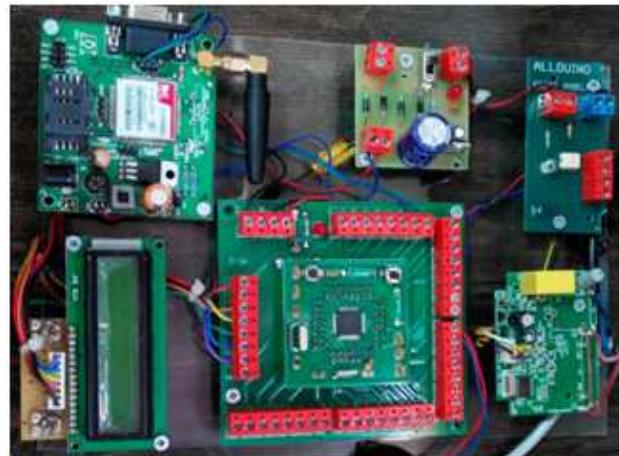


Figure 3: System Hardware Prototype

The result of software implementation for monitoring power consumption is shown below in Figure 5 and Figure 6

Figure 5 gives the live wattage consumption of remote device connected to hardware prototype. The same wattage is also logged on to SQL server database.



Figure 4: Monitoring Window

Below figure 6 shows the plot for live wattagerecorded from the remote device. This would enable to keep track of power consumption of different devices at different time of the day.



Figure 5: Live Power Usage Graph

Below is sample bill report for the user specified period based on unit calculation for the power consumption information recorded in database and as per pre decided charges per unit.



Figure 6: Usage bill

CONCLUSIONS

Energy savings and an increased security of supply are main drivers of smart metering systems.

By realization of above proposed system one can monitor household energy consumption as well receive accurate billing for the energy usage as the manual intervention and hence possibility of errors is eliminated. It will also reduce human efforts required to collect the meter readings thus helping the grid companies and can give insight into areas where the consumption should be controlled and thus serve energy conservation.

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